

We Claim:

1. An improved method which increases the operating range of a combustion burner that controls the ratio of flue gas to air in a flue gas-air oxidizer stream which method comprises:

contacting the combustion generator with fuel and full excess air, recirculated flue gas, and combinations thereof wherein the modulation and control of the recirculated flue gas-air ratio is useful to reduce the size of at least one fan in the recirculated flue gas line, one fan in the air line or combinations thereof and results in reducing the power requirements of at least one fan and reduces the emission of nitrogen oxides.

2. An improved method for operating gas, liquid or solid fuel combustion burners or combinations thereof that utilizes recirculated flue gas, full excess air and combinations thereof which method increases the operating range of the burner by operating from a high recirculated flue gas percentage at low heat input to a lower recirculated flue gas percentage at high heat input under conditions to minimize the change in oxidizer volumetric flow relative to change in the oxidizer mass flow, which method comprises:

- a. contacting a combustion generator with a combustible fuel, wherein said combustion generator is located within a combustion chamber ;
- b. utilizing an air inlet to provide full excess air to the combustion generator;
- c. utilizing an exhaust stack for exhausting flue gas from the combustion chamber wherein said exhaust stack has a stack inlet coupled to the combustion chamber and a take-off point;
- d. utilizing a recirculation inlet and a recirculation outlet for flue gas wherein said recirculation inlet is coupled to said take-off point;
- e. combining in a mixing zone, recirculated flue gas, air, and combinations thereof for transport of recirculated flue gas and air through the burner;

5 f. contacting the combustion generator with fuel and recirculated flue gas and air mixtures, wherein the modulation control between the recirculated flue gas and excess air mixtures has flow control means for controlling the oxidizer flow between the recirculated flue gas and excess air ratio during operation to result in a mass of diluent which is provided to the said combustion chamber resulting in the reduced fan size about 50% or less of conventional and the operational electrical power needed for the at least one fan is about 50% or less of a comparable fan for a conventional combustion system.

10 3. The method of Claim 2 wherein in step e the mixing zone is selected from:

- 15 (i) a common fan having a flue gas inlet, an air inlet and an outlet to the combustion chamber ;
- (ii) a chamber having a flue gas recirculation line which contains at least one fan and a separate air line which contains at least one fan and an outlet line; or
- 20 (iii) an air line which includes at least one fan connected to the combustion chamber and a flue gas recirculation line which includes an optional fan having a fuel line immediately downstream of the optional fan which line exits to the combustion chamber.

25 4. The method of Claim 1 wherein in step f the control of the recirculated flue gas-air ratio utilizes an adjustable damper or an on-off damper in the flue gas recirculation line.

5. The method of Claim 1 wherein in step e the at least one fan is selected from the group consisting of constant speed, variable frequency drive and combinations thereof.

30 6. The method of Claim 1 wherein in step e the means for modulation control is selected from manual, electro-pneumatic, digital control or analog control.

35 7. The method of Claim 1 wherein in step e the means for modulation control is digital control modulation and the level of nitrogen oxides is less than about 20 ppm.

8. The method of Claim 1 wherein in step a the combustion generator uses gas, liquid or solid fuel.

5 9. The method of Claim 1 wherein in step a the combustion fuel is natural gas and in step e the means for modulation is digital control and the level of nitrogen oxides emitted is about 9 ppm or less.

10 10. The method of Claim 1 wherein in step e the means for control is selected from an adjustable damper, an on-off damper, a transfer fan, or combinations thereof, and the level of nitrogen oxides emitted is less than about 9 ppm.

15 11. The method of Claim 7 wherein in step (a) the fuel is natural gas, in step (c) a fan in each line is present as described in subpart (ii), and the modulation is digital control.

20 12. An apparatus for a gas, liquid, or solid fuel combustion burner or combinations thereof that controls the ratio of flue gas to air in a recirculated flue gas-air oxidizer stream during operation which is useful to reduce the size of at least one fan in the flue gas recirculation line, air line or combinations thereof and reduce the power consumption of at least one fan in the flue gas line, air line or combinations thereof which concurrently increases the operating range of the apparatus.

25 13. An apparatus for operating gas, liquid, or solid fuel combustion burners or combinations thereof that utilizes flue gas recirculation, excess air and combinations thereof which apparatus increases the operating range of the burner by operating from a high recirculated flue gas percentage at lower heat input to a lower recirculated flue gas percentage at high heat input under conditions to minimize the change in oxidizer volumetric flow relative to change in the oxidizer mass flow, which apparatus comprises:

- 30 A. a combustion generator located within a combustion chamber,
- B. an exhaust stack for exhausting flue gas from the combustion chamber wherein said exhaust stack has a stack inlet coupled to said combustion generator and a take-off point,

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- C. a recirculation inlet and a recirculation outlet wherein for flue gas said recirculation inlet is coupled to said take-off point,
- D. a separate air inlet to provide full excess air to said combustion generator,
- E. a mixing zone for combining recirculated flue gas, air and combinations thereof for transport of recirculated flue gas and air through the burner; and
- F. means within the flue gas recirculation line for modulation control between recirculated flue gas and excess air to result in a substantially constant higher mass of air and flue gas diluent at a given fuel flow is provided to said combustion chamber which results in reduced fan size of about 50% or less and results in operational electrical power of about 50% or less than the conventional for the at least one fan needed for full excess air.

14. The apparatus of Claim 11 wherein in subpart F the means for control of the recirculated flue gas-air ratio is selected from an adjustable damper, an on-off damper, digital control or combinations thereof.

15. The apparatus of Claim 11 wherein in subpart F the at least one fan is selected from the group consisting of constant speed, variable frequency drive (VFD) and combinations thereof.

16. The apparatus of Claim 11 wherein in subpart F the means for modulation is selected from electro-pneumatic or digital control.

17. The apparatus of Claim 15 wherein in subpart F the means for modulation control is digital control and the level of nitrogen oxides is less than about 20 ppm.

18. The apparatus of Claim 11 wherein in subpart F the level of nitrogen oxides is less than about 9 ppm.

19. The apparatus of Claim 11 wherein in subpart A the combustion fuel is selected from gas, liquid or solid fuel.

20. The apparatus of Claim 15 wherein the combustion fuel is natural gas and the level of nitrogen oxides emitted is less than about 9 ppm.

21. The apparatus of Claim 11 wherein in subpart F the means for control of the flue gas-air ratio is selected from an adjustable damper, a transfer fan, or combinations thereof and the level of nitrogen oxides emitted is less than about 9 ppm.

22. The apparatus of Claim 11 wherein in subpart E the means for modulation control is E (iii), the fan is not present, and a high pressure fuel gas stream enters the flue gas recirculation line that induces flow of flue gas and the combination exits to the combustion chamber.

23. In a method for operating gas, liquid or solid fuel combustion burners that utilizes flue gas recirculation, full excess air and combinations thereof which method increases the operating range of the burner by operating from a high flue gas recirculation percentage at lower heat input to a lower flue gas recirculation percentage at high heat input under conditions to minimize the change in oxidizer volumetric flow relative to change in the oxidizer mass flow, wherein the improvement comprises:

utilizing an adjustable damper or an on-off damper located within the flue gas recirculation line and means for modulating said damper, and the result is the fan size in the oxidizer gas lines are reduced about 50% as the operating power requirement is reduced about 50% compared to the conventional fan, or the level of nitrogen oxides is reduced to about 50 ppm or less.